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Effect Of Microwaves On The Resistance Of Aloe Vera Leaves

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ABSTRACT

For centuries plants has been exposed to natural electromagnetic sources such as radiation from sun, space, and earth. Today, in addition to this natural radiation and owing to immediate technological progresses these plants are further exposed to man-made electromagnetic radiation (EM). A variety of products and applications in our day to day life makes use of a number of forms of electromagnetic energy. One such form of energy is Microwave. Microwaves are non-ionizing electromagnetic radiations. These are electromagnetic waves with wavelengths ranging from as long as one meter to as short as one millimetre, or equivalently, with frequencies between 300 MHz (0.3 GHz) and 300 GHz. These frequencies may affect the quality of micro waved treated Aloe Vera leaves. The effect of microwave on Aloe Vera leaves was studied. Aloe Vera plant has been chosen in view of the fact that it has numerous applications in dermatology. It is also famous as "Lily of Desert". The leaves of Aloe Vera contain a soothing thick sap that is valuable for healing and curing of wounds and diseases. The objective of this study is to investigate the changes in electrical properties of Aloe Vera plants after exposure to different amount of microwaves. It was found that the on exposure to microwaves the Aloe Vera Leaves first showed a marked increase in the current across it with a slight increase in the voltage but afterwards it adjusted itself to the normal value.

Keywords **-** Aloe Vera, D. C. resistance, Effect of microwaves, Klystron, Microwave test bench, Surface electrodes.

I. INTRODUCTION

Since atmosphere microwave window allows diffusion of cosmic rays with frequencies ranging within GHz domain, there is always a microwave element within the environment emission background [1]. Microwave spectrum falls in between the Infra-Red (IR) and the Radio frequency (RF) segment of the electromagnetic radiation. Microwaves are electromagnetic waves with wavelengths ranging from as long as one meter to as short as one millimeter, or equivalently, with frequencies between 300 MHz (0.3GHz) and 300GHz. This broad definition includes both UHF and EHF (millimeter waves), and various sources use different boundaries. In all cases, microwave includes the entire SHF band (3 to 30 GHz, or 10 to 1cm) at minimum, with RF engineering often putting the lower boundary at 1 GHz (30 cm), and the upper around 100 GHz (3 mm). Microwaves are used in plywood, paint, inks, synthetic rubber, and medical related manufacturing industries [2]. Microwaves are non ionizing radiations. These radiations are the part of the electromagnetic spectrum. Wireless telecommunication devices enhance the exposure of radio and microwave frequencies in the environment. The energy content of the electromagnetic (EM) waves is related to the frequency as:

$E = h\nu$ where E = Electric field, h = Plank's constant, and ν = frequency.

The plants have cellular receptors which are use to observe changes in their surroundings. These changes are of different types and differ from plant to plant. All living organisms generate and conduct electrochemical impulses all the way through their different tissues and organs. It has been demonstrated experimentally the properties of temperature sensing in plants [3]. The plants also show reaction to the exciting electrical signals. These signals may set off different physiological reactions [4]. The main physical signal in any organism is electrical signal. The electrical signals are capable of transmitting signals at a long distance. Recently, biologists have revealed that the significance of physiological activities depends upon the electrical signals [5]. Plants play a significant role in the living world as main producers of food and oxygen, therefore it would be advantageous to investigate their relations with today's increased exposure to radio and microwave frequency fields. The effect of microwave causes alteration in electrical properties of Aloe Vera plants. The new and energetic area of scientific research is the studies associated to the microwave effects. Microwave effects can be generally classified into thermal and non thermal. It is well known that microwave fields have poor biological effects at high power levels. But, effects at low power levels have not been fully implicit. Radiations are known to encourage physiological and genetic modifications [6-9]. The

objective of this paper is to investigate the changes in electrical properties of the Aloe Vera leaves exposed to microwave radiations. The details of Aloe Vera plant is presented in Section II. The methodology is given in Section III and results & discussions in Section IV along with the conclusions in Section V.

II. ALOE VERA

Aloe Vera is a stem less plant having a height of 60–90 cm (24–36 inches) tall, spreading by offsets. The stem has dormant root buds that develop to form new roots. The leaves are thick and fleshy, green to grey-green, with some varieties showing white flecks on the upper and lower stem surfaces [10]. Aloe Vera plant gel is a lively ingredient in a number of different skin care products that facilitates to treat a wide variety of different problems of skin. Healing properties of Aloe Vera plant make it so beneficial for skin care. It helps in restoring skin's natural beauty this is one of the most important benefits of Aloe Vera. The plant can survive in hot temperatures ranging from 40 degrees Celsius down to freezing temperatures as far as the root of the plant is not damaged [11]. Its thick leaves include the water supply for the plant to survive long periods of drought. These leaves have a high capability of retaining the water. Transparent gel from the pulp of the fleshy leaves of Aloe Vera has been used topically for thousands of years to treat wounds, skin infections, burns, and numerous other dermatologic conditions. Dried latex from the inner lining of the leaf has traditionally been used as an oral laxative [12]. Aloe Vera gel is used as an ingredient in commercially available lotions, yogurt, beverages, and some desserts [13-14]. The use of Aloe Vera gel in cosmetics has a function analogous to anti-aging effects of vitamin A derivatives [15].

A. Water Storing Mechanism of Aloe Vera

The Aloe Vera store water in their enlarged fleshy leaves stems or roots as shown below. This allows them to survive in arid environments. The Aloe Vera leaf has a clear, inner, fleshy, portion. It is rich in nutrients and very healthy for both internal and external consumption. Fig. 1. shows Split Aloe Vera leaf with fleshy clear inner part.

B. Physiology of Aloe Vera

Aloe Vera is a perennial liliaceous plant which has juicy green leaves attached at the stem in a whorled pattern. It has thick fibrous root which produces large basal leaves. The leaves are one to two feet long, and three to four centimeters wide, gradually tapering to a point. They are whitish green on both sides and bear spiny teeth on the margins. Fig. 2. shows the whorled pattern of Aloe Vera leaves.

Fig. 1. Split Aloe Vera leaf with fleshy clear inner part.

Fig. 2. Whorled pattern of Aloe Vera leaves.

C. Anatomy of Aloe Vera

It consists of three main parts:

1. **Aloe Vera Rind**: The protective, green, outer covering of the leaf is called Aloe Vera Rind.
2. **Aloe Vera Latex**: This is the middle part of the Aloe Vera leaf which is bitter. It is in between the inner fleshy part and outer part like a sap. This sap is contained in special tubules which form a portion of the nutrient tubes of the vascular bundles located just beneath the wax-covered, thick green rind of the leaf.
3. **Aloe Vera Gel**: This is the inner portion of the leaf and is very fleshy. It is rich in nutrients and is recommended for consumption. The gel, which consist the bulk of the leaf substance, serves as the water storage space organ for the plant. This gel, which may be separated as a semi-solid "fillet" before processing, contains more than 200 different substances. Chief among these are polysaccharides, glycol proteins, vitamins, mineral and enzymes.

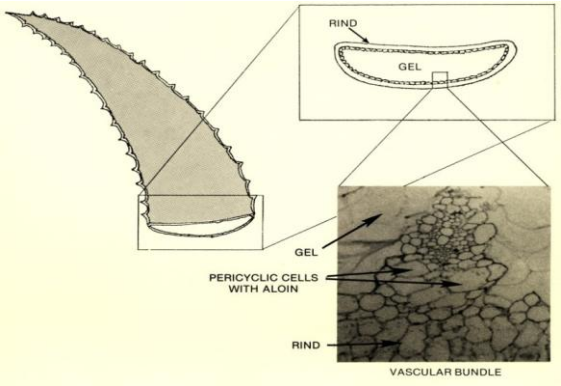

Fig. 3. Anatomy of Aloe Vera leaf.

D. Economical Importance of Aloe Vera

It is highly appreciated because of its use in pharmaceutical industries, folk medicine, healthcare, cosmetic and food industries. It also has high economic value among all the plant species [16]. In homeopathic medicine Aloe Vera is used for haemorrhoids. In India Aloe Vera has been referred to as "Kumari' in Ayurveda treatments. A number of selected Aloe Vera species are valued for their beauty and ornamental value.

E. Electrical Properties of Aloe Vera

1. **Electrical Resistance:** Resistance is the opposition offered by the Aloe Vera Plant when the current is passed through the Aloe Vera tissue .The phenomenon of polarization occurs, when the current is passed through it, i.e. at the level of each electrode a double layer of ions get deposited which acts as an insulator prevents the current from passing.
2. **Electrical Capacitance:** Capacitance is the ability of a body to store an electrical charge. When the current is passed through the Aloe Vera tissue it gets electrically charged and the charge is stored in the form of energy. It acts like a parallel plate capacitor.

If the charges on the plates are $+q$ and $-q$, and V give the voltage between the plates, then the capacitance C will be:

$$C = \frac{q}{V}$$

That gives the voltage/current relationship:

$$I(t) = C\frac{dV(t)}{dt}$$

Thus, for a fixed value of capacitance, the rate of change of voltage is directly proportional to current.

III. METHODOLOGY

The investigations were carried out on the leaves of the Aloe Vera plant to study the effect of microwaves on the electrical resistance of the leaves. The plant was grown in a pot containing fertile soil under natural environmental conditions. In this research, microwave setup was installed and these microwaves were applied on the Aloe Vera leaf to record any change in the resistance of the leaf. The experimental setup can be understood below in Fig. 4.

Fig. 4. Microwave setup for exposure of Aloe Vera leaf to microwaves.

First of all the Aloe Vera leaf was taken and the two surface electrodes were attached on the leaf at a distance of 6.5 cm. With these two electrodes the electrical connections were established as shown below in the Fig. 5, where e1 and e2 are surface electrodes on the Aloe Vera leaf.

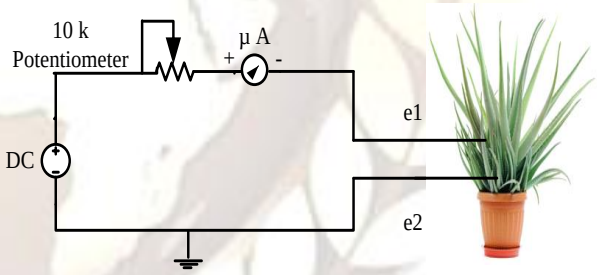

Fig. 5. Circuit diagram for calculating resistance of the Aloe Vera leaf.

The voltage as well as current across the leaf was measured without exposing it to microwaves. Then the microwave setup was established that consisted of Klystron along with the Klystron power supply. The voltage across the Klystron power supply when switched on was 300 V. Klystron is a specialized liner-beam vacuum tube which is used as an amplifier for high frequencies. Here the klystron is used as a waveguide for coupling microwave energy into and out of the device. Now, the two surface electrodes were attached to the Aloe Vera Leaf at a distance of 6.5 cm and further this Aloe Vera leaf bearing electrodes was kept at a distance of 41 cm away from the Klystron in between the two horns having a gap of

10 cm from each other. The distance between the Aloe Vera leaf was 5 cm from either horn. The length & width of the horn was 15 cm & 10 cm respectively. After that the apparatus consisting of Aloe Vera leaf bearing electrodes and the horns was wrapped with the thin aluminum foil and was exposed to microwaves for every 2400 seconds.

IV. RESULTS AND DISCUSSIONS

Investigations were carried out using microwaves for the determination of the electrical properties of the Aloe Vera plant. An Aloe Vera tissue acts as an ionic conductor and when the direct current is passed through an ionized solution the well-known phenomenon of polarization occurs, i.e. very rapidly at the level of each electrode a double layer of ions gets deposited which acts as an insulator and prevents the current from passing. Aloe Vera leaf was given microwave exposure for same durations of 2400 s, 4800 s, 7200 s, 14400 s and this experiment was repeated 4 times on the same Aloe Vera leaf. The results are explained in Table I.

Table I. Resistance calculated every 2400 s of microwave exposure.

Microwave Exposed Time (s)	Voltage (V)	Current (μA)	Resistance (MΩ)
0	4.78	6	0.79
2400	4.78	9	0.53
4800	4.81	6	0.8
7200	4.78	5	0.95
14400	4.79	5.5	0.87

The Resistance (in mega ohms) curve of this circuit is represented in Fig. 6 below with respect to the Time, where VCR variations are variation in voltage, current and resistance in volts, microampere and mega ohms respectively. For the first 2400 s of the exposure to microwaves the current across the Aloe Vera leaf was increased to 9 μA from 6μA which was without exposure to microwaves. The voltage across the leaf remained constant i.e. 4.78 V and the resistance calculated was 0.53 mega-ohms. After that the leaf was again exposed to microwaves for next 4800 s, 7200 s and 14400 s and it was found that the current first adjusted itself to 6 μA, 5 μA and 5.5 μA respectively and the voltages recorded were 4.81 V, 4.78 V, and 4.79 V respectively.

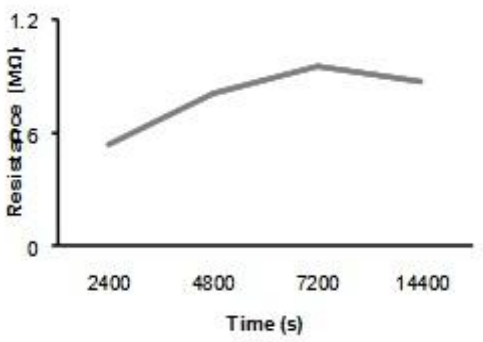

Fig. 6. Resistance curve of Aloe Vera leaf with respect to the exposed time.

The calculated values are represented in form of Histogram.

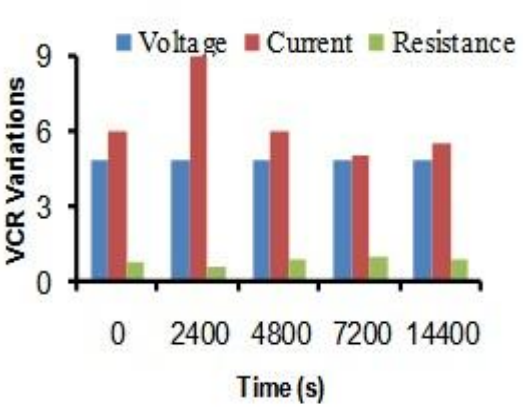

Fig. 7. Variation of voltage, current and resistance of Aloe Vera leaf with respect to the exposed time.

V. CONCLUSION

The investigations were carried out to study the variation of resistance in the Aloe Vera leaves. The experiments have shown that the resistance of the Aloe Vera leaves showed a specific non-linear function of time of microwave exposure. Also it shows that whenever the dc power supply is given to the Aloe Vera leaf, before microwave exposure it offers a high resistance to the applied voltage and after the microwave exposure the resistance decreases slightly and then readjusts itself to the normal value. Moreover this idea of electrical processes in plants may lead to elaboration of new approaches and mean of objective diagnostics of physiological state of the plants.

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